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RESEARCH ARTICLE



# LoveYourBrain Mindset: Feasibility, Acceptability, Usability, and Effectiveness of an Online Yoga, Mindfulness, and Psychoeducation Intervention for People with Traumatic Brain Injury

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## ABSTRACT

**Objective:** Despite the benefits of yoga, mindfulness, and psychoeducation after traumatic brain injury (TBI), no online programming exists. This study investigated the feasibility, acceptability, usability, and effectiveness of the LoveYourBrain Mindset online program for people with TBI.

**Research Design:** Pre-post, retrospective intervention.

**Methods:** LoveYourBrain Mindset is a six-week online yoga, mindfulness, and psychoeducation program with weekly interactive Zoom classes and prerecorded mindfulness tools. Two interactive class types (45-minute group discussion, 75-minute group discussion and gentle yoga) are offered to enhance accessibility. People were eligible if they experienced TBI, were a caregiver, or clinician;  $\geq 15$  years old; and capable of gentle exercise and group discussion. We analyzed attendance, program ratings, mindfulness tools utilization, and pre/post-intervention differences in QOL, resilience, emotional/behavioral dysregulation, cognition, and positive affect/well-being.

**Results:** Overall, 1539 individuals signed up for LoveYourBrain Mindset with 1093 (71.02%) participating in one/more classes. The mean program rating was 9.09 (SD=1.28). Majority (62.99%) used the mindfulness tools each week. Multiple linear regression models controlling for age, TBI severity, and gender indicated significant improvements in QOL, resilience, emotional/behavioral dysregulation, cognition, and positive affect/well-being ( $p < 0.001$ ).

**Conclusion:** LoveYourBrain Mindset is feasible, acceptable, usable, and may improve outcomes among people with TBI.

## ARTICLE HISTORY

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## KEYWORDS

Traumatic brain injury; rehabilitation; psychotherapeutic rehabilitation

## Introduction

Traumatic brain injury (TBI) is a leading cause of death and disability in the United States (1). TBI is a form of acquired brain injury that occurs when a sudden trauma causes brain damage, resulting in a mild, moderate, or severe TBI diagnosis (2). This injury is complex and often leads to debilitating effects physically (e.g., headache, dizziness, poor balance, loss of coordination), cognitively (e.g., executive functioning, poor memory, cognitive fatigue), psychologically (e.g., anxiety, depression), and behaviorally (e.g., disorientation, irritability) (2,3). Furthermore, these symptoms may prolong far beyond the time of injury, causing long-term loss from work or school, decreased social engagement, and lower quality of life (QOL) (4–11). Despite the prevalence and serious impacts of TBI, there is no gold standard rehabilitation process that can address the multifaceted nature of the injury (12,13).

Yoga is a holistic, adaptable activity that encompasses physical postures combined with meditation and breathing techniques to promote physical and emotional well-being. Yoga has been shown to improve physical symptoms, cognitive impairment, and behavioral changes associated with TBI (14–20). Specifically, research

investigating the use of yoga in TBI populations has shown improvements in balance (16,18), strength (18), endurance (18), mobility (16), focus (19), self-awareness (19), confidence (18), depression (20), resilience (14), QOL (14), and well-being (14). Research investigating the effectiveness of mindfulness-based techniques (i.e., meditation, breathing exercises, visualization) for TBI rehabilitation has also reported improvements in physical and behavioral symptoms (21), attention (22), and QOL (21,22). In addition, TBI psychoeducation focuses on providing people with knowledge about how to better understand and cope with their injury (23) and, when combined with other forms of rehabilitation such as yoga and meditation, may improve post-TBI outcomes (24). Furthermore, yoga-based interventions are highly conducive to group formats, which facilitate greater social interaction and may enhance mental health and mitigate loneliness associated with TBI (25).

Despite the multiple benefits of group-based yoga, mindfulness, and psychoeducation for TBI rehabilitation, to our knowledge, no online programming with this focus exists. This is not surprising given that people affected by TBI often experience symptoms [e.g., headaches and visual impairments leading to screen sensitivity, sensory overload, difficulty seeing (2,3)] that

can undermine their ability to access and benefit from online rehabilitation services. However, the COVID-19 pandemic has dramatically increased the demand for and necessity of online services to promote health and wellbeing after TBI. To address this gap, the LoveYourBrain Foundation developed an online LoveYourBrain Mindset program. This manualized, free, six-week yoga, mindfulness, and psychoeducation program is delivered online to people with TBI, caregivers, and clinicians. The goal of this program is to increase QOL, resilience, and community participation using methods to empower participants to recognize and manage negative thoughts about self-worth and to participate in social groups that foster purpose and belonging (26).

The LoveYourBrain Mindset curriculum was adapted from the evidence-based LoveYourBrain Yoga program – a community-based six-week yoga, mindfulness, and psychoeducation program delivered in-person through yoga studios across the United States and Canada (14,27–29). Specifically, the LoveYourBrain Mindset curriculum consists of two components: 1) a weekly interactive, live, online class via Zoom and 2) four prerecorded mindfulness tools emailed weekly. To enhance accessibility of the interactive component (e.g., provide a shorter class option for people with screen sensitivities) and promote person-centered care, participants choose between two interactive class types: 1) 45-minute group discussion class or 2) 75-minute group discussion and gentle yoga class. An initial study of 809 LoveYourBrain Mindset participants using the same programming as the current study found high attendance, engagement, and satisfaction with the program. However, the initial study did not evaluate the effectiveness on improving TBI clinical outcomes (QOL, resilience, emotional and behavioral dysregulation, cognition, and positive affect and well-being) or the potential impact of interactive class type on the results (28).

Given the novelty of this rehabilitation approach, research is needed to understand its effectiveness and success in meeting the needs of people affected by TBI. These data will have important implications on how to increase access to holistic rehabilitation services for this marginalized community during the COVID-19 pandemic and beyond using a person-centered care approach. Therefore, this study aimed to investigate the LoveYourBrain Mindset program's feasibility, acceptability, usability, and effectiveness on improving TBI clinical outcomes of QOL, resilience, emotional and behavioral dysregulation, cognition, and positive affect and well-being, both in aggregate and by interactive class type.

## Methods

### Study Design

This pre-post intervention study evaluated data collected by the LoveYourBrain Foundation before and after participation in the six-week LoveYourBrain Mindset online program. The study received approval from the Dartmouth College Committee for the Protection of Human Subjects (Study #02000421) and adhered to the STROBE reporting guidelines for cohort studies (30).

### Participants

Participants were eligible for the study if they had participated in LoveYourBrain Mindset between September 2020 and June 2021 and gave their permission to LoveYourBrain for their data to be used for research purposes. To be eligible to participate in LoveYourBrain Mindset, individuals must have self-identified as either a TBI survivor, caregiver of someone with a brain injury, or clinician, were aged 15 years or older, had no medical restrictions to participating in gentle exercise, and were able to participate in group discussion. Those who signed up for the interactive class type with group discussion and gentle yoga must have also been able to move without assistive devices (e.g., wheelchair, cane) unless granted special permission.

### Intervention

LoveYourBrain Mindset is a free, manualized, six-week online yoga, mindfulness, and psychoeducation program for people with TBI and caregivers of those with TBI. Occasionally, clinicians serving patients with TBI are also invited to participate so that they can become more familiar with the program to then be able to refer their patients to participate. Following pilot testing in May/June 2020 in response to the COVID-19 pandemic, LoveYourBrain formally launched LoveYourBrain Mindset in October 2020. The six-week program includes two weekly components: 1) an interactive, live, online Zoom class (choice of two class options: 45-minute group discussion class or 75-minute group discussion and gentle yoga class) and 2) four prerecorded mindfulness tools sent to participants via e-mail (described below). Each week, the online class and mindfulness tools focus on a specific theme – resilience, mindfulness, intentions, realistic optimism, positive thinking, and gratitude – to support participants to cultivate a Growth (vs. Fixed) Mindset as a key strategy toward building resilience and social connection (31). With a Growth Mindset, people are better able to transform challenge and adversity into catalysts for learning and growth (32).

The LoveYourBrain Mindset curriculum was adapted from the evidence-based, six-week in-person LoveYourBrain Yoga program (14,27–29). Several curriculum adaptations were made from the in-person format to facilitate successful participation in the online format. First, to help mitigate symptoms from extended screen time, the group discussion and gentle yoga class time was reduced from 90 minutes to 75 minutes. During this class, the first half includes the research backed LoveYourBrain Yoga sequence then transitions into the group discussion for the latter half. The LoveYourBrain Yoga sequence is similar to the in-person curriculum, but, to promote safety, includes more adaptations and prioritizes postures where participants are facing the camera (e.g., seated, all fours, and standing over supine or prone poses). Second, to increase accessibility for people with the greatest screen sensitivity and/or seeking peer support instead of physical activity, the LoveYourBrain Mindset curriculum offers a second interactive class option with only group discussion that was shorter in duration (i.e., 45 minutes). Participants choose between these two types of interactive classes based on their needs and

interests. The interactive classes are hosted on Zoom by LoveYourBrain-trained Facilitators and co-Facilitators. Third, given the potential for distractions in participants' physical environment that could detract from the online experience, all programs included tools for promoting attention and social connection (e.g., establishing community agreements of respect, vulnerability, confidentiality, and inclusion), opening check-ins to ascertain participant and group energy levels on a scale from 1 to 10, and opening and closing guided mindfulness meditations to consciously transition in and out of the program time. Finally, all participants receive an e-mail with access to weekly prerecorded mindfulness tools, described as follows:

- (1) 1–5-minute psychoeducational videos with narration by a cartoon brain character about the theme of the week.
- (2) 7–10-minute audio-recorded meditations based on the LoveYourBrain Yoga curriculum, which includes adaptations (e.g., eyes open or closed, slow and repeated instruction) to improve awareness, focused attention, mood, and other impacts of TBI (29).
- (3) 45–55-minute videos of gentle hatha yoga classes based on the LoveYourBrain Yoga curriculum, which includes adaptations (e.g., minimal to no inversions, slow and repeated instruction, chair modifications) to support balance, vestibular challenges, and other TBI symptoms and co-morbidities (29).
- (4) 16–45-minute audio-recorded yoga nidra guided relaxation practices designed to activate the parasympathetic nervous system and decrease sleep disturbance, stress, anxiety, depression, and chronic pain after TBI (33,34).

Participants are asked to watch the brief psychoeducational video before attending the interactive class so that they can learn about the topic of the week and reflect on the question prompt in preparation for their group conversation. Participants are asked to complete the other tools, including the meditations, yoga classes, and yoga nidra-guided relaxation practices, on their own time whenever works best for them that week. See [Table 1](#) for a description of the weekly themes, psychoeducation objectives, question prompts to guide the group discussion, and the specific mindfulness tools. The full curriculum is available upon request.

Logistically, LoveYourBrain Mindset programs are offered in quarterly cycles (e.g., January, April, July, and October). In each cycle, LoveYourBrain intentionally offers more programs with group discussion and gentle yoga interactive classes than programs with just group discussion based on the historic demand for the longer class type and lack of TBI-specific gentle yoga in the TBI rehabilitation space. A maximum of 13 people can enroll per program group to facilitate equitable participation in the group discussion and to maintain a low participant-to-Facilitator ratio. Program groups with less than seven participants enrolled are canceled to ensure sufficient participation for a meaningful group discussion and for LoveYourBrain's financial viability. Individuals can participate in the program multiple times at no cost. To deliver to each program group, LoveYourBrain pays one lead Facilitator and one assistant co-Facilitator chosen from a network of 60 LoveYourBrain-trained Facilitators and co-

Facilitators. Facilitators and co-Facilitators follow a structured manual to guide each class as a method to promote intervention fidelity. Facilitators can schedule free mentorship calls with LoveYourBrain staff at any time during their program to discuss unforeseen challenges and receive individualized support. LoveYourBrain staff also observe one interactive class for new Facilitators so that they can monitor and provide feedback to enhance program quality and fidelity.

### **Data Collection**

Data included in this study comprised self-reported quantitative data collected by the LoveYourBrain Foundation electronically in eligibility and feedback form surveys from LoveYourBrain Mindset participants between September 2020 and June 2021. Up to six weeks prior to their participation, individuals were required to complete an electronic eligibility form with questions about their eligibility, demographic characteristics, injury history, clinical outcomes, where they learned about the program, and permission to use data for research purposes. At the end of the six-week program, participants who took one or more classes were sent an electronic feedback form including the same clinical outcomes as well as questions about program acceptability and usability. Feedback forms were not sent to participants who were 'no shows' or withdrew before the program started. Participants received two automated follow-up e-mails requesting that they complete the feedback form at one-week intervals.

### **Measures**

#### **Sociodemographic Characteristics and Injury History**

Participants were asked to self-report whether they identified as a person with TBI, caregiver, or clinician, their age, race, gender, educational attainment, geographic location, and previous yoga experience. People with TBI were also asked to report their age at injury, injury mechanism, injury severity (i.e., mild, moderate, or severe), duration of loss of consciousness, and select from a list of current TBI-related symptoms and co-morbidities (35).

#### **Feasibility**

Feasibility is the extent to which the implementation of a study can practically be completed (36). Feasibility was assessed by describing the total number of people who signed up, withdrew, or were no shows, the number of programs offered in total and by interactive class type, and the number of programs canceled.

#### **Acceptability**

Acceptability is how well a study is received by the target population and the extent to which the protocol meets the needs of the population (37). Program acceptability was assessed using the following question, 'On a scale from 1 to 10, how would you rate this program? (1 = poor, 10 = excellent)' among the overall sample and by interactive class type.

#### **Usability**

Usability is the extent to which subjects can complete the provided content (38). Usability was assessed by describing the self-reported use of the prerecorded mindfulness tools (i.e., gentle yoga class, meditation, yoga nidra guided relaxation, and

**Table 1.** Overview of weekly themes and psychoeducation objectives, questions, and tools.

Week	Theme	Objective	Question Prompts	Tools
1	Resilience	Educate participants about the concept of resilience and how to apply it to the TBI experience. Build group cohesion through shared experiences and vulnerability.	What's your one min story of your connection to the brain injury community? Whether you've experienced a TBI or are a caregiver, what's one thing that has helped you become more resilient?	<ul style="list-style-type: none"> <li>• 1.5 min video, 'Power of Resilience'</li> <li>• 7 min mountain visualization meditation</li> <li>• 45 min gentle yoga class</li> <li>• 20 min yoga nidra guided relaxation, 'I am entering into a deep and restful sleep'</li> </ul>
2	Mindfulness	Educate the group about what mindfulness is and build skills in how to apply mindful awareness to support healing from TBI and managing related challenges as a caregiver (e.g., stress).	How does mindfulness show up in your life? How could mindfulness be a helpful strategy for your own healing and wellbeing? Share your experience with meditation, what have you found to be helpful or challenging?	<ul style="list-style-type: none"> <li>• 1.5 min video, 'Power of Mindfulness'</li> <li>• 9 min body scan meditation</li> <li>• 45 min gentle yoga class</li> <li>• 16 min yoga nidra guided relaxation, 'I embrace what is present'</li> </ul>
3	Intentions	Educate the group about intention setting as a tool for addressing negative thoughts and creating new, more helpful ways of thinking.	Share an intention that's important to you right now. How do you use it in your daily life to support your healing or wellbeing?	<ul style="list-style-type: none"> <li>• 1.5 min video, 'Power of Intention'</li> <li>• 11 min progressive muscle relaxation meditation</li> <li>• 45 min gentle yoga class</li> <li>• 16 min yoga nidra guided relaxation, 'I am doing the best I can'</li> </ul>
4	Realistic Optimism	Educate the group about a strengths-based approach to managing the impacts of TBI.	What's one challenging outcome of your brain injury/experience as a caregiver and how are you growing from it? What's an area in your life you're working on right now, and how have you overcome obstacles along the way?	<ul style="list-style-type: none"> <li>• 1.5 min video, 'Power of Realistic Optimism'</li> <li>• 9 min color visualization meditation</li> <li>• 45 min gentle yoga class</li> <li>• 17 min yoga nidra guided relaxation, 'I release my judgment'</li> </ul>
5	Positive Thinking	Educate the group about using positive thinking/self-talk to interrupt self-limiting thoughts that undermine our ability to heal and thrive.	What is one positive outcome of your TBI that you maybe didn't expect?	<ul style="list-style-type: none"> <li>• 1.5 min video, 'Power of Positive Thinking'</li> <li>• 8 min finding love within meditation</li> <li>• 45 min gentle yoga class</li> <li>• 28 min yoga nidra guided relaxation, 'I am complete, while and perfect as I am'</li> </ul>
6	Gratitude	Educate the group about the value of gratitude for counteracting negative feelings and orienting the mind to better appreciate what we have instead of focusing on what we don't.	What is one thing you are grateful for?	<ul style="list-style-type: none"> <li>• 1.5 min video, 'Power of Gratitude'</li> <li>• 9 min loving kindness meditation</li> <li>• 55 min gentle yoga class</li> <li>• 45 min yoga nidra guided relaxation, 'I am enough'</li> </ul>

Abbreviations: TBI, traumatic brain injury.

psychoeducation video) among the overall sample and by interactive class type. Participants reported how many of the gentle yoga classes, meditations, yoga nidra guided relaxation practices, and psychoeducational videos they completed from 'none' to 'all six,' and also reported how many weeks (i.e., 'zero' to 'six' weeks) they completed any of the tools by responding to the question: 'During how many weeks did you do some of the material (video, meditation, yoga class, yoga nidra)?'

### Effectiveness

Five valid and reliable TBI-specific outcomes were used to determine the effectiveness of the LoveYourBrain Mindset program among the overall sample and by interactive class type.

*Quality of Life.* QOL was assessed using the QOL After Brain Injury overall scale (QOLIBRI-OS). This scale has a good reliability (Cronbach's  $\alpha = 0.86$ , test-retest

reliability = 0.81) in TBI patients (39). Participants were asked six questions related to overall life satisfaction after brain injury on a five-point scale (1 = not at all, 2 = slightly, 3 = moderately, 4 = quite, and 5 = very). Responses were summed to give a total, divided by the number of responses to produce a mean (range 1–5) and converted to a 0–100 scale. Higher scores indicated higher QOL.

**Emotional and Behavioral Dysregulation.** Emotional and behavioral dysregulation was assessed using the Neurology QOL (Neuro-QOL) Emotional and Behavioral Dysregulation Short Form (v1.0 SF8). Participants were asked eight questions related to their ability to control their emotions and behaviors on a five-point scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, and 5 = always). Scores were summed and transformed into a standard t-score. Higher scores indicated more emotional and behavioral dysregulation.

**Resilience.** Resilience was assessed using the TBI-QOL Resilience Short Form (v1.0 SF10a). TBI-QOL is a set of self-report measures adapted from the Neuro-QOL measures specific to the TBI population and have demonstrated validity, responsiveness to change, measurement stability, and the internal consistency is good (Cronbach's  $\alpha = 0.952\text{--}0.974$ ) (40). Participants were asked 10 questions related to their ability to overcome adversity on a five-point scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, and 5 = always). Scores were summed and transformed into a standard t-score. Higher scores indicated higher resilience.

**Cognition.** Cognition was assessed using the TBI-QOL Cognition Short Form (v1.0 SF10a). Participants were asked 10 questions related to their overall cognitive abilities on a five-point scale [1 = always (several times a day), 2 = often (about once a day), 3 = sometimes (two or three times), 4 = rarely (once), and 5 = never]. Scores were summed and transformed into a standard t-score. Higher scores indicated more difficulties with general cognition.

**Positive Affect and Well-Being.** Positive affect and well-being were assessed using the TBI-QOL Positive Affect and Well-Being Short Form (v1.0, SF9a). Participants were asked nine questions related to their life's well-being and purpose on a five-point scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, and 5 = always). Scores were summed and transformed into a standard t-score. Higher scores indicated higher positive affect and well-being.

## Statistical Analyses

Feasibility measures were analyzed using descriptive statistics and included participants who had submitted an eligibility form. Based on LoveYourBrain's minimum requirement of seven participants to operate a program, we considered LoveYourBrain Mindset to be feasible if at least 80% of programs met this threshold.

Acceptability and usability measures were analyzed using descriptive statistics and included data from unique participants with TBI who had submitted a feedback form after their first time participating in LoveYourBrain Mindset. Based on previous research on the acceptability of LoveYourBrain Yoga (14), we considered LoveYourBrain Mindset to be acceptable if the mean satisfaction rating was  $>9.0$  overall and by subgroup.

Given the novelty of this program, no benchmark was applied for the usability of the mindfulness tools. Independent two-sample t-tests were used to assess differences in acceptability and usability by interactive class type.

Analyses of effectiveness comprised non-missing, linked clinical outcome data in eligibility and feedback forms from unique participants with TBI. If people participated in a program more than once, data from their first-time participation were included and data from subsequent times were excluded. For each of the clinical outcomes, we conducted separate multiple linear regression models to investigate changes in pre- and post-program scores. All models controlled for age, TBI severity, and gender. We performed subgroup analysis by interactive class type to examine whether the effects were mediated by this factor. To account for the multiple comparisons, statistical significance was assessed at a  $p < 0.01$ . All analyses were conducted using SAS.

## Results

### Feasibility

A total of 127 LoveYourBrain Mindset programs were opened for enrollment during the study period, including 88 programs with group discussion and gentle yoga classes and 39 programs with group discussion classes. All programs met the enrollment criteria for implementation (registration of  $\geq 7$  participants) and were successfully implemented (i.e., no programs were canceled).

Overall, 1,539 people signed up for a LoveYourBrain Mindset program, including the 411 who were eligible for this study's acceptability, usability, and effectiveness analyses. A total of 1,285 individuals signed up for the program once, 210 signed up twice, 40 signed up three times, and four signed up four times. Of those who signed up for LoveYourBrain Mindset, 1,093 (71.02%) participated in one or more of their chosen interactive classes, 425 (27.62%) were no-shows, and 21 (1.36%) withdrew or canceled. Unique participants (i.e., those who completed the program once or, if completed more than once, data from the first participation was only included) reported primary reasons for participating in LoveYourBrain Mindset as 1,148 (89.34%) people who had experienced a TBI, 107 (8.33%) caregivers, 27 (2.10%) clinicians, two (0.16%) yoga instructors, and one (0.08%) identifying other.

### Acceptability and Usability

A total of 607 feedback forms were submitted (response rate = 55.54%), including 411 from unique participants with TBI from the first time they had participated in LoveYourBrain Mindset. These individuals were utilized for the acceptability, usability, and effectiveness analyses. Sociodemographic and injury-related characteristics of the sample of 411 unique, first-time participants with TBI with non-missing data who were used for these analyses are reported in Table 2. Overall, 82.11% ( $n = 335$ ) participants identified as female and 87.47% ( $n = 356$ ) as white. Participants reported a wide range of TBI causes including 36.43% ( $n = 145$ ) motor vehicle accident, 19.35% ( $n = 77$ ) fall, 15.58% ( $n = 62$ ) being struck by or against

**Table 2.** Sociodemographic and injury characteristics of the full sample and by interactive class type.

	Full Sample (n = 411)		Yoga Sample (n = 269)		Group Discussion Sample (n = 142)	
	Mean	SD	Mean	SD	Mean	SD
Current Age	44.97	12.53	45.26	12.27	44.42	13.04
Age at Last TBI	40.90	12.98	41.20	12.72	40.32	13.48
Age Since Last TBI	4.22	5.64	4.06	4.88	4.52	6.86
	n <sup>a</sup>	%	n <sup>b</sup>	%	n <sup>c</sup>	%
Gender						
Female	335	82.11	228	85.39	107	75.89
Male	68	16.67	35	13.11	33	23.40
Genderqueer, Neither Exclusively Male nor Female	4	0.98	3	1.12	1	0.71
Additional Gender Category/Other	1	0.25	1	0.37	0	0.00
Race						
White	356	87.47	240	90.23	116	82.27
Black/African American	10	2.46	5	1.88	5	3.55
American Indian/Alaska Native	1	0.25	0	0.00	1	0.71
Asian	12	2.95	6	2.26	6	4.26
Native Hawaiian/Other Pacific Islander	1	0.25	5	1.88	1	0.71
Other	11	2.70	5	1.88	6	4.26
Multiracial	16	3.93	10	3.76	6	4.26
TBI Cause						
Fall	77	19.35	48	18.25	29	21.48
Motor Vehicle Accident	145	36.43	103	39.19	42	31.11
Sports-Related	49	12.31	29	11.03	20	14.81
Assault	12	3.02	6	2.28	6	4.44
Work-Related	23	5.78	17	6.46	6	4.44
Struck by or Against an Object	62	15.58	41	15.59	21	15.56
Other	30	7.54	19	7.22	11	8.15
TBI Severity						
Mild	176	44.22	126	47.91	50	37.04
Moderate	136	34.17	86	32.70	50	37.04
Severe	86	21.61	51	19.39	35	25.93
Loss of Consciousness						
Yes, <30 Minutes	95	23.87	62	23.57	33	24.44
Yes, >30 Minutes, <1 Day	26	6.53	15	5.70	11	8.15
Yes, >1 Day	50	12.56	30	11.41	20	14.81
No	170	42.71	118	44.87	52	38.52
Not Sure	57	14.32	38	14.45	19	14.07
Current Conditions <sup>d</sup>						
None	10	2.43	8	2.97	2	1.41
Anxiety	301	73.24	195	72.49	106	74.65
Depression	237	57.66	153	56.88	84	59.15
Difficulty Communicating	164	39.90	105	39.03	59	41.55
Difficulty Hearing/Deaf	40	9.73	19	7.06	21	14.79
Difficulty Seeing	88	21.41	54	20.07	34	23.94
Headaches	297	72.26	209	77.70	88	61.97
Light Sensitivity	254	61.80	172	63.94	82	57.75
PTS/PTSD	161	39.17	100	37.17	61	42.96
Paralysis on One Side of the Body	10	2.43	3	1.12	7	4.93
Post-Concussion Syndrome	272	66.18	178	66.17	94	66.20
Seizures	21	5.11	12	4.46	9	6.33
Sleep Disturbance	236	57.42	153	56.88	83	58.45
Weakness on One Side of the Body	67	16.31	39	14.50	28	19.72

<sup>a</sup>Participants in the full sample who did not self-report data for gender (n = 3), race (n = 4), TBI cause (n = 13), TBI severity (n = 13), and loss of consciousness (n = 13) were not included. Percentages add up to 100% of self-reported responses.

<sup>b</sup>Participants in the yoga program sample who did not self-report data for gender (n = 2), race (n = 3), TBI cause (n = 6), TBI severity (n = 6), and loss of consciousness (n = 6) were not included. Percentages add up to 100% of self-reported responses.

<sup>c</sup>Participants in the yoga program sample who did not self-report data for gender (n = 1), race (n = 1), TBI cause (n = 7), TBI severity (n = 7), and loss of consciousness (n = 7) were not included. Percentages add up to 100% of self-reported responses.

<sup>d</sup>Participants could report as many current conditions as applied to them. Therefore, percentages add up to greater than 100%.

Abbreviations: TBI, traumatic brain injury; PTS, post-traumatic stress; PTSD, post-traumatic stress disorder.

an object. Overall, 44.22% (n = 176) reported their TBI severity as mild.

Based on the number of programs offered by interactive class type, a majority participated in group discussion and gentle yoga classes (65.45%, n = 269) versus group discussion classes (34.55%, n = 142). The sociodemographic characteristics and injury history of both groups were comparable.

The mean program quality rating was a 9.09 (SD = 1.28, range 1–10). There were no significant differences in ratings by the interactive class type, with participants in the group

discussion and gentle yoga class reporting a mean of 9.11 (SD = 1.26) and those in the group discussion class reporting a mean of 9.07 (SD = 1.34, p = 0.74).

Usability ratings of the mindfulness tools are provided in Table 3. Overall, a majority of participants (62.99%) reported completing some material during each of the six weeks. There were no differences between the interactive class types in the overall number of weeks the tools were utilized or in the frequency of use of the meditations, yoga nidra guided relaxation practices, and psychoeducation videos (p > 0.01, Table 4).

**Table 3.** Reported use of the mindfulness tools over the six-week LoveYourBrain Mindset program (n = 411).

Weeks Completed	Any Material Completed		Gentle Yoga Class		Meditation		Yoga Nidra Meditation		Psychoeducation Video	
	n <sup>a</sup>	%	n <sup>a</sup>	%	n <sup>a</sup>	%	n <sup>a</sup>	%	n <sup>a</sup>	%
0 (No Weeks)	0	0.00	75	19.43	47	12.18	97	25.13	7	1.18
1	13	3.41	36	9.33	28	7.25	42	10.88	6	1.55
2	17	4.46	35	9.07	35	9.07	57	14.77	11	2.85
3	19	4.99	36	9.33	59	15.28	48	12.44	22	5.70
4	38	9.97	48	12.44	65	16.84	35	9.07	33	8.55
5	54	14.17	52	13.47	28	7.25	21	5.44	40	10.36
6 (All Weeks)	240	62.99	104	26.97	124	31.12	86	22.28	267	69.17

<sup>a</sup>Participants who did not self-report data for overall use (n = 30) or use of the yoga (n = 25), meditation (n = 25), yoga nidra (n = 25), and video materials (n = 25) were not included. Percentages add up to 100%.

**Table 4.** Comparison of the mean number of weeks the mindfulness tools were completed by interactive class type.

	Yoga Sample (n = 269)		Group Sample (n = 142)		p-value
	Mean Number of Weeks Completed	SD	Mean Number of Weeks Completed	SD	
Any Material Completed	5.24	1.30	5.01	1.45	0.10
Psychoeducation Video	5.27	1.42	5.23	1.31	0.83
Gentle Yoga Class	4.17	1.93	1.83	2.08	<0.001*
Meditation	3.60	2.14	3.81	2.00	0.35
Yoga Nidra Meditations	2.81	2.29	2.64	2.21	0.49

Abbreviations: SD, standard deviation.

\*p<0.01.

**Table 5.** Mean scores on clinical outcomes pre- and post-intervention among people with TBI (n = 411).

Outcome	Pre-Intervention		Post-Intervention	
	Mean	SD	Mean	SD
QOL	43.92	17.23	53.54	16.86
Resilience	43.89	6.49	46.12	6.85
Emotional and behavioral dysregulation	55.09	7.85	53.34	7.06
Cognition	32.87	7.18	34.24	6.89
Positive affect and well-being	48.42	5.51	50.29	6.00

Abbreviations: SD, standard deviation; QOL, quality of life.

However, there was a significant difference in the frequency of use of the gentle yoga videos (p < 0.001, Table 4) between these groups.

### Effectiveness

Mean scores for pre- and post-intervention effectiveness outcomes are reported in Table 5. Multiple linear regression models controlling for age, TBI severity, and gender indicated a significant improvement in QOL (p < 0.001, MD = 0.59, 95% CI = 0.51, 0.67), resilience (p < 0.001, MD = 0.70, 95% CI = 0.62, 0.78), emotional and behavioral dysregulation (p < 0.001, MD = 0.58, 95% CI = 0.52, 0.65), cognition (p < 0.001, MD = 0.74, 95% CI = 0.68, 0.80), and positive affect and well-being (p < 0.001,

MD = 0.77, 95% CI = 0.70, 0.85). Subgroup analyses by interactive class type revealed consistent trends (Table 6).

### Discussion

This study aimed to evaluate the feasibility, acceptability, usability, and effectiveness of the novel LoveYourBrain Mindset online program. Our findings suggest that LoveYourBrain Mindset meets strong feasibility, acceptability, and usability standards, and may significantly improve QOL, resilience, emotional and behavioral dysregulation, cognition, and positive affect and well-being among people with TBI.

Our results have important implications for potentially integrating LoveYourBrain Mindset as an accessible and

**Table 6.** Multiple linear regression models evaluating pre- and post-intervention changes in clinical outcomes among the full sample and by interactive class type.

Outcome	p-value	Full Sample (n = 411)		Yoga Sample (n = 269)		Group Sample (n = 142)	
		MD	95%CI	MD	95%CI	MD	95%CI
QOL	<0.001*	0.59	0.51,0.67	0.56	0.46,0.66	0.64	0.51,0.76
Resilience		0.70	0.62,0.78	0.69	0.59,0.79	0.71	0.59,0.84
Emotional and behavioral dysregulation		0.58	0.52,0.65	0.55	0.46,0.63	0.64	0.53,0.74
Cognition		0.74	0.68,0.80	0.73	0.65,0.81	0.75	0.65,0.85
Positive affect and well-being		0.77	0.70,0.85	0.76	0.67,0.85	0.80	0.67,0.93

Note: All models controlled for age, gender, and TBI severity.

Abbreviations: MD, mean difference; 95%CI, 95% confidence interval, QOL, quality of life.

\*p<0.01.



effective means of rehabilitation to improve life following TBI. Indeed, research has consistently found that patients with mild to severe TBI often do not receive adequate rehabilitation services, education about prognosis, or follow-up care (12,41). Thus, it is promising that the improvements in clinical outcomes found in our study were robust to TBI severity, suggesting that the program may be impactful for a broad range of TBI patients. This is particularly relevant for the many people with TBI (including those in our study sample) who experience long-term symptoms (i.e., anxiety, depression, light sensitivity, and headaches) and impairments that last beyond their post-injury acute clinical care. It is also promising that the benefits remained consistent between interactive class type, which indicates that having these two options embedded in the program design may support person-centered care. As such, LoveYourBrain Mindset may empower people with TBI experiencing persistent symptoms and impairments with ongoing access to choose from a range of rehabilitation services (i.e., gentle yoga, meditation, and psychoeducation) to facilitate improvements in symptoms and QOL.

Our results are consistent with research on the benefits of the in-person LoveYourBrain Yoga program (14), which suggest the online format may be leveraged to improve accessibility without compromising effectiveness. Indeed, access to in-person activities can be compromised after brain injury as a result of fear of leaving home, transportation limitations, and time restrictions (42–44). TBI symptoms commonly reported by our sample (e.g., post-concussion syndrome, anxiety, depression, sleep disturbance, PTS/PTSD, headaches, light sensitivity) have been shown to make driving or accessing transportation difficult and/or require caregiver assistance (45,46). Because the online LoveYourBrain Mindset program is delivered remotely, offers different options for interactive classes based on duration and physical activity preferences, and empowers participants to self-manage their activity levels, it may address some of these barriers for both people with TBI and caregivers (47). We recommend future research include controlled studies comparing the effectiveness of in-person LoveYourBrain Yoga and online LoveYourBrain Mindset to further understand the unique benefits of online yoga, mindfulness, and psychoeducation for TBI rehabilitation.

The consistent weekly use of some of the mindfulness tools suggests the viability of this format of online content delivery for the TBI population. Notably, the psychoeducational videos were utilized the most frequently. Their popularity may have been driven by their brevity since they were substantially shorter in duration than all other tools. It may also reflect that the topics (i.e., resilience, mindfulness, intentions, realistic optimism, positive thinking, and gratitude) resonate strongly with participants. Therefore, we recommend that other TBI rehabilitation programs consider integrating similar psychoeducational topics rooted in growth mindset/positive psychology (32) and using audio-visual functionality to deliver key messages. In contrast, the yoga nidra-guided relaxation practices had the lowest reported use, despite over half of participants currently experiencing sleep disturbance and thus may have particularly benefited from this tool. This trend may have been attributed to the longer length of these meditations and/

or less familiarity with the specific benefits of yoga nidra meditation in comparison to the other tools. To increase utilization, we recommend integrating into the curriculum a more detailed explanation of why yoga nidra can be helpful for TBI rehabilitation (33,34).

The high program quality ratings and attendance suggest LoveYourBrain Mindset is feasible and acceptable when delivered online to the TBI population. Indeed, all programs that were opened for enrollment were successfully implemented, despite more than a quarter of prospective participants not showing up to their program's first interactive class. The high program quality ratings and attendance trends did not differ by type of interactive class, suggesting that offering two different options successfully met participants' needs. However, participants in the interactive class type with only the group discussion reported significantly less use of the gentle yoga videos than participants in the interactive class type with group discussion and gentle yoga. This discrepancy may simply reflect the different preferences between these two groups and reinforce the value of offering two class options (one with organized movement and one without) for increased accessibility. And yet, this discrepancy may also reflect that the videos were not sufficiently accessible for participants in the interactive classes with group discussion, possibly because of the higher proportion of people with physical mobility limitations (e.g., paralysis, hemiparesis) in this group. Therefore, we recommend including more accessible videos with a wider range of modifications for people using assistive devices, such as a chair-based yoga class or sequences that avoid transitions from floor to standing. Also, given that a majority of participants had a mild TBI and experienced post-concussion syndrome, including videos of more vigorous yoga practices [e.g., vinyasa (48) or ashtanga (49)] to increase aerobic activity may enhance the program's benefits for people with mild TBI (50–54).

### **Study Strengths and Limitations**

This study has several strengths and limitations. Pre-post, single-arm design is subject to confounding; therefore, we recommend future studies utilize a randomized controlled design to assess intervention effectiveness more reliably. Current analyses only included those with TBI who had completed the eligibility and feedback questionnaires, which may have introduced a response bias. The convenience sample led to an overrepresentation of white women, and, thus, we recommend future studies focus on including minority groups to explore the generalizability of the results among groups with disproportionately higher barriers to accessing quality rehabilitation services (55). We also recognize that greater efforts must be made to reach people without internet access, such as providing additional resources for internet support. The limitations notwithstanding some of the strengths of this study include a sample that represented diversity in TBI severity, suggesting that the results may be broadly generalizable across the continuum of TBI severity. The study maximized ecological validity by being conducted in a 'real world' setting, therefore avoiding volunteer bias intrinsic to randomized

controlled trials. Finally, several strategies were employed to promote intervention fidelity [e.g., manualized format of the LoveYourBrain Mindset curriculum, mentorship calls, Facilitator observation (56)].

## Conclusions

LoveYourBrain Mindset is an unprecedented, online, TBI-focused yoga, mindfulness, and psychoeducation program with design features that promote accessibility and person-centered care. Our findings suggest that, when implemented on a large scale, it is feasible, acceptable, usable, and may be effective at improving QOL, resilience, emotional, and behavioral dysregulation, cognition, and positive affect and well-being among people with TBI. Future research is necessary to determine the potential benefits of this program and how best to maximize the online delivery so that the TBI community can access high-quality rehabilitation services throughout their healing journey.

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## Disclosure statement

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